Notre Dame University. Department of Mechanical Engineering
Test #2-MEN210 (Thermodynamic I) *Open book: 1hr 30 minutes*
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Problem#1(15pt)

Air enters a 0.6 m diameter fan at 16°C and 101kPa (absolute pressure), and is discharged at 18°C and 105kPa and exit volume flow rate of 0.5 m^3/s. Find the mass flow rate of air in kg/s and the inlet and exit velocities in m/s. R= 287J/kg-K for air.

Problem#2(4,3,8pt)

1. What is Carnot cycle?
2. Is the following statement true or false? "It is impossible for any system to operate in such a way that the sole result would be an energy transfer by heat from a cooler body to a hotter body".
3. If a refrigerator that requires a power input of 900 W cools a freezer compartment at a rate of 8000 kJ/hr, what is the coefficient of performance for the refrigerator? What is the rate at which heat is transferred to the surrounding room?

Problem#3(7,8pt)

A cycle has a heat input of 2500 kJ/kg, produces 950 kJ/kg of electric power, requires 10kJ/kg of power to move the working fluid, and has waste heat in the amount of 1560 kJ/kg.

a) What is the thermodynamic efficiency, η, of the cycle?
b) If the plant produces 100MW of electrical power, what is the mass flow rate of the working fluid, in kg/s?

Problem #4(20pt)

An ideal gas is contained in a closed rigid tank fitted with an electric resistor. The electric resistor adds energy to the system at a rate of 100 W and energy leaves the system via heat transfer at a rate of 25 W. If the mass of gas is 3 kg and the temperature change over 12 minutes is 50 K, determine the constant volume specific heat, C_v, in units of kJ/kg-K.

$_1Q_2$ = 0.36 $C_v = \frac{du}{dT}$

Problem#5(15pt)

An ideal gas at 600kPa and 700 K is confined to one side of a rigid, insulated container divided by a partition. The other side is initially evacuated. The partition is then removed and the gas expands to fill the entire container. The initial volume is 0.3 m^3 and the final volume is 0.8 m^3. Find the final pressure in the container.

$PV = mR$ $PV = mRT$ 25 − 100 = 0 + m(u₂ − u₁) = m(Cv dT)

Problem#6(20pt)

In our everyday life disorder means a lot of places where our lost key may be found. The greater the number of possible traveled locations, the greater the disorder to find the key is. Disorder is measured with the help of special quantity – entropy S.

If entropy is defined as such: S = k ln Γ. Where k is Boltzmann's constant and Γ is the number of microstates. A molecule is confined to a final space that cannot travel to the other 5 sections of the overall space. The molecule was in an initial free space that can move freely inside. $k = 1.38 \times 10^{-23}$ J/K.

Find the dS of the system and explain the disorder.

$dq = C_p(T_2 - T_1)$ $_1Q_2 = m(u_2 - u_1) = m(C_v(T_2 - T_1))$

$Q = m(u_2 - u_1) + W$

$mR = \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ $_1Q_2 + W = m(u_2 - u_1)$

$\frac{P}{T}$ $\frac{PV}{T} = \frac{PV}{T}$

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Zouk Mosbeh - Lebanon

$\frac{77}{80} \rightarrow \frac{96}{100}$

(94)

$\frac{80+96}{2} + \frac{12}{2}$

Name : ....

Course N°: MEN210 Section : ....

Grade : ....

I.D. N° : ..

Date : ....

Problem 15

$P_{ex} V_{ex} = R T_{ex}$ $v_{ex} = \frac{287 \times 291 \cdot 10^{-3}}{105}$

$= 795.4 \cdot 10^{-3}$ m³/kg

$\dot{V}_{ex} = A V_{elocity}$

$\dot{m}_{ex} = \dot{m}_i = \frac{\dot{V}}{v_{ex}} = \frac{0.5 \text{ m}^3/\text{s}}{795.4 \cdot 10^{-3} \text{ m}^3/\text{kg}} = 0.628 \text{ kg/s}$

$\dot{m}_{ex} = \dot{m}_{in} = \frac{A \, Vel_{in}}{v_{in}} \rightarrow Vel_{in} = \frac{\dot{m}_{in} \times v_{in}}{A}$

$A = \pi \times 0.3^2$ $v_{in} = \frac{R T_i}{P_i} = \frac{287 \cdot 10^{-3} \times 289}{101}$

$= 0.821$ m³/kg

so $Vel_{in} = \frac{0.628 \times 0.821}{\pi \times 0.3^2} = 1.82$ m/s

$vel_{ex} = \frac{\dot{V}_{ex}}{A} = \frac{0.5}{\pi \times 0.3^2} = 1.76$ m/s

Problem # 2

1- A carnot cycle is a reversible cycle and the cycle by which we can have the highest efficiency. clearer

(-1)

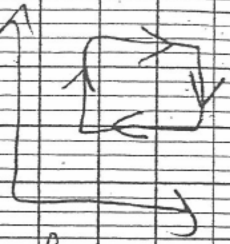
The carnot cycle has ~~the~~ some four basic processes

~~two~~ ~~2~~ reversible Isothermal process ~~on which~~ ~~heat~~

and ~~three~~ adiabatic process

It can be shown by

or



refrigerator v heat engine

2) True because using the clausius statement we should have work to transfer heat from cooler body to hotter body.

3) $\dot W = 900\,W$ $\dot Q_L = 8000\,kJ/h$
$= \frac{8000\,kJ}{3600}/s = 2.23\,kW$

$(COP) = \beta = \frac{2.23\,kW}{0.9\,kW} = 2.46$

The rate of heat transfered is $\dot Q_H$: $\dot Q_H = \dot W + \dot Q_L$
$= 0.9 + 2.23$
$= 3.13\,kW$

Problem #3 We can see that it is a heat engine with $\frac{\dot Q_H}{\dot m} = 2500\,kJ/kg$

a) W of turbine $= \frac{\dot W}{\dot m} = 950\,kJ/kg$

$\frac{\dot W_{pump}}{\dot m} = 10\,kJ/kg$ and $\frac{\dot Q_L}{\dot m} = 1560\,kJ/kg$

$W_{el} - W_{pump}$

$$\eta = \frac{W_{net}}{Q_H} = \frac{W_{net}/m}{Q_H/m} = \frac{950 - 10}{2500} = 0.376$$

b) $\dot{W} = 100\ MW = 100 \cdot 10^3\ KW$

$\frac{\dot{W}}{\dot{m}} = 950\ Kj/Kg$

$\dot{m} = \frac{\dot{W}}{950} = \frac{100 \cdot 10^3\ KW}{950\ Kj/Kg} = 105.26\ Kg/s$

Problem # 4: first law for control mass.

${}_1Q_2 - W = m(u_2 - u_1)$ neglecte potential and Kinetic energy.

$\dot{Q}_1 - \dot{W} = m\frac{du}{dt}$

but $du = c_v\, dT$

organize: $\frac{dQ}{dt} - \frac{dW}{dt} = m\, c_v \frac{dT}{dt}$

$100 - 25 = 3 \times c_v \left(\frac{50}{12\ min}\right)$

$c_v = \frac{75\ W \times 12\ min}{50 K \cdot 3\ Kg} = \frac{75\ W \times 4 \times 60\ s}{50 K \times 1\ Kg}$

$c_v = 360\ J/Kg\text{-}K = 0.36\ KJ/Kg\text{-}K$

$\frac{dQ}{dt} = c_p(T_2 - T_1)$

$\frac{dQ}{dt} = c_v(T_2 - T_1) \Rightarrow c_v\ \frac{100 - 25}{3 \times 50}$

THE DEBATE CLUB

Problem # 5: The other side is evacuated
{ no work on the boundary $W = 0$
Insulated ~~S~~ ... $Q_2 = 0$

~~$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ $\frac{600 \times 0.3}{700}$~~

Rearrange ~~$\frac{P_2}{T_2} = \frac{600 \times 0.3}{700 \times 0.8} = 0.321$~~

−1

Insulated so
$dq = 0 = C_p(T_2 - T_1) = 0$
Then $T_2 = T_1$

$P_2 = 225\ KPa$

Then $S_2 - S_1$
The is insulated ~~S_2 - S_1 = ...~~
Then $m = 1$
$P_1 V_1 = P_2 V_2 = m R T_1$
$P_2 = \frac{P_1 V_1}{V_2} = 225\ KPa$

~~$W = m R (T_2 - T_1) \ldots$~~

Work is 0 since the pressure on the boundaries ~~en~~ on its boundary when the partition is removed

Problem 6:
~~The disorder is that every process when it is done~~

Total 19

$S_2 - S_1 = 1.38 \times 10^{-28} \times (\ln 5) - 1.38 \times 10^{-2} \times \ln(10)$

$= 1.38 \times 10^{-28} \times \ln(5)$

−8